ON TEMPERATURE MEASUREMENTS IN TRANSIENT INTERACTIONS BETWEEN GASEOUS BODIES AND DIABATIC WALLS

BY

ROBERT BEACHAM DILLAWAY

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An investigation was undertaken to study the mechanism of rugged fast responding thermometric devices in contact with the surface region of finite bodies whose temperature is rapidly changing. In particular an experimental investigation was made of the correlation of the response of elements mounted in the surface of bodies exposed to a finite air mass whose temperature was suddenly changed.

A theoretical study was made for the case of thin film and fine wire sensing elements in order to obtain response times of 100 microseconds, or less, when a step temperature change occurred in the body adjacent to the element surface. A one-dimensional model of the thermometric devices, or gages, was chosen for the calculation of interactions involving a square pulse of radiant energy on the gage surface, and for interaction with a finite gas body at rest whose temperature was discontinuously changed.

Gages having the required speed of response were developed in the initial phase of the experimental program. They were of thin film and fine wire types mounted on ceramic backings. After static calibration, the speed of response was studied by subjecting the element to a square pulse of radiant energy. For the purpose of comparison, the response of the all-metal Midwest Research Institute was studied by subjecting the element to a square pulse of radiant energy. For the purpose of comparison, the response to the all-metal Midwest Research Institute film-type thermocouple was also studied under these conditions. As a result of the radiant energy tests on the two film type gages a new characteristic time was proposed, for relating the gage thermal properties to the response of the gages when the latter were subjected to radiant energy. This characteristic time is independent of the intensity of the radiation. The interaction studies of the fast responding gages, both film and fine-wire types, with finite air bodies were conducted in the Department of Aeronautical Engineering shock tube. The elements under study were mounted flush with the interior surface of the tube walls, of both steel and transite construction, and were subjected to step

steel and transite construction, and were subjected to step changes in air body temperature of from 30°F. to 2000°F.

The responses obtained from these tests indicate that the heat transfer from the air body to the wall, behind the reflected shock waves, is essentially conduction in the laminar layer although turbulence does exist in the gas interior. In spite of certain advantages inherent with thermocouple devices, the thermocouple gage elements of the single junction type were not suitable in this type of application where the gas temperature rise is less than 1000°F. However, the resistance thermometers did respond to gas body temperature rises of 150°F. in the case of the film type gage and 30°F. in the case of the wire type gage elements. It was shown that usable fast responding thermometric devices could be fabricated by evaporating thin metal films on non-metallic backings.

VITA

Robert Beacham Dillaway was born in Washington, D.C., November 10, 1924. Upon graduation from Calvin Coolidge High School, Washington, D.C. in 1942, he spent one year as a research aid at the Naval Research Laboratory in Washington, D.C.

After receiving Bachelor of Science Degrees in Mechanical Engineering and Mathematics from the University of Michigan in 1945, he spent one year as a development engineer with Carrier Corp. of Syracuse, New York and taught mathematics in the extension school of Syracuse University. The following two years he was associated with Engineering Research Associates, Inc., in Washington, D.C. as a Research Engineer.

In the fall of 1948 he was appointed as an Instructor of Mechanical Engineering at the University of Illinois, Urbana, Illinois. He also began study in the graduate college of the same institution, receiving his Master of Science degree in Physics in 1950.

He was a Donovan Scholar in his senior year at the University of Michigan and was elected a member of Sigma Xi and Pi Mu Epsilon.